Video Quality Research

Outputs

- Digital video quality measurement technology.
- Journal papers and national/international video quality measurement standards.
- Technical input to development of U.S. policies on advanced video technologies.
- A national objective and subjective digital video quality testing laboratory.

Digital video systems are creating many new telecommunication services and industries (e.g., direct broadcast satellite, digital television, high definition television, video teleconferencing, telemedicine, e-commerce) that are becoming an essential part of the U.S. and world economy. Objective metrics for measuring the performance of these systems are required for specification of system performance, comparison of competing service offerings, network maintenance, and use optimization of limited network resources. The goal of the ITS Video Quality Research project is to develop the required technology for assessing the performance of these new digital video systems and to actively transfer this technology to other government agencies, end-users, standards bodies, and the telecommunications industry, thereby producing increases in quality of service that benefit end-users and service providers.

To be accurate, digital video quality measurements must be based on perceived "picture quality" and must be made in-service. This is because the performance of digital video systems is variable and depends upon the dynamic characteristics of both the input video and the digital transmission system. To solve this problem, ITS developed a new measurement paradigm that is based upon extraction and comparison of low bandwidth perception-based features that can be easily communicated across the telecommunications network. This new measurement paradigm has received three U.S. patents, been adopted as an ANSI standard, and is being used by organizations worldwide. Figure 1 demonstrates the ability of the ITS measurements to perform continuous in-service quality monitoring. This graph shows an example time history of single stimulus continuous quality evaluation (SSCQE) data from an MPEG-2 test and corresponding quality predictions from a 10 kbit/s reduced reference quality monitoring system (i.e., the extracted features have 10 kbit/s of total bandwidth). A 100 on the scale is excellent quality while a 0 is bad quality. During FY 2002, two SSCQE experiments were conducted and this subjective data was used to optimize the ITS metrics for an automatic quality monitoring of MPEG-2 digital television systems.

Also during FY 2002, ITS completed development of a UNIX-based and Windows®-based automated video quality measurement (VQM) tool. This VQM tool can be downloaded from the Video Quality Research home page given below. Version 2.0 of the VQM software includes detailed documentation of the technical algorithms, a user's manual, and test video sequences to verify proper software installation. The VQM software performs all necessary processing steps on the sampled input and output video streams, including:

1. Calibration. A video system may introduce spatial shifts of the picture (both horizontal and vertical), a reduction of the picture area (valid region), changes in gain (i.e., contrast) and offset (i.e., brightness), and temporal shifts of the video stream (i.e., video delay). The process of estimating and removing these four items from the destination

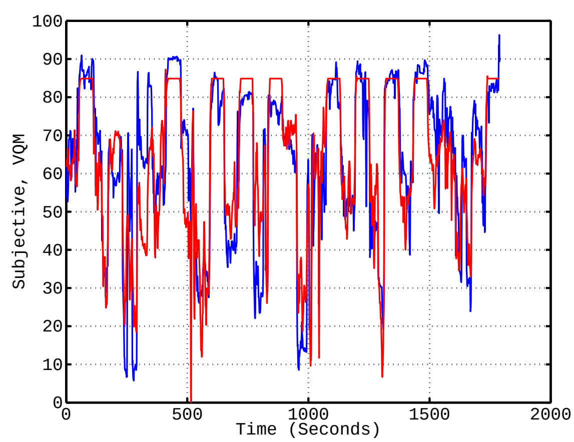

Figure 1. SSCQE subjective data (blue) and corresponding objective quality predictions (red).

video stream is referred to as calibration or normalization. Many deployed video systems have been observed to have poor system calibration. If not properly accounted for, this can create erroneous results with very poor correlation to subjective quality ratings.

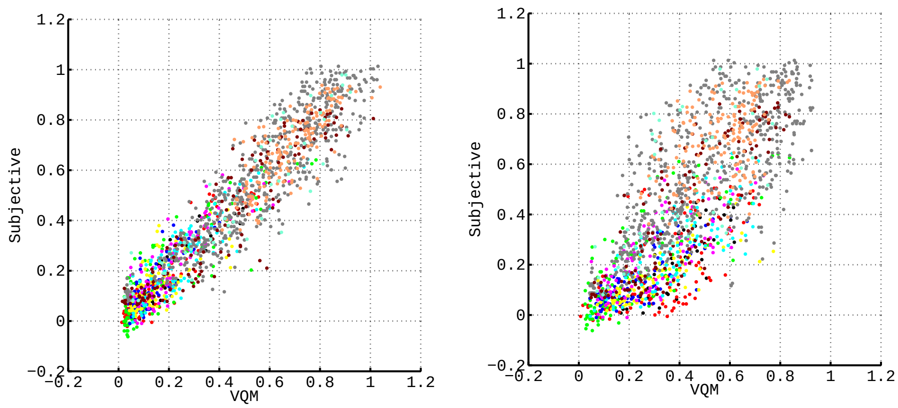

Figure 2. Performance of two video quality mappings: General Purpose – left, PSNR– right.

2. Feature Extraction. The input and output video streams are divided into spatial-temporal (S-T) regions from which features, or summary statistics, are extracted that quantify the perceptual aspects of video quality. Two types of features are extracted from the luminance signal Y: features based on spatial gradients and features based on temporal gradients. Features derived from spatial gradients are used to characterize perceptual distortions of edges and detail, while features derived from temporal gradients quantify distortions in the flow of motion. Some coding and transmission impairments create special color impairments (e.g., a colored error block, localized color shifts). A useful feature to quantify these types of impairments is based on the mean two-dimensional chrominance vector (Cb, Cr) computed over each S-T region.

3. Distance Measures. The perceptual impairment at each S-T region is calculated using functions that model visual masking of the spatial and temporal impairments. Loss and gain are normally examined separately, since they produce fundamentally different effects on quality perception (e.g., loss of spatial detail due to blurring and gain of spatial noise due to blocking). Of the many comparison functions that have been evaluated, two forms have consistently produced the best correlation to subjective ratings. These visual masking functions imply that impairment perception is inversely proportional to the amount of localized spatial or temporal activity that is present.

4. Quality Mapping. A video quality mapping, or model, is a particular algorithm that is used to combine a set of distance measures into an overall estimate of quality. The quality mapping can depend upon many things, including the type of subjective experiment and video application. Currently, fifteen subjective data sets that span a very wide range of scenes and video systems are used as truth data for the development and testing of objective video quality mappings. The VQM software that is available for download implements five different quality mappings. Figure 2 gives the performance of two of these quality mappings: a "General Purpose" mapping using ITS-developed metrics and a traditional Peak Signal to Noise Ratio (PSNR) mapping. Eleven data sets are shown where each data set is plotted in a different color. The Y-axis is the actual subjective score while the X-axis is the quality mapping. The data has been scaled such that "0" is mapped to no perceived impairment and "1" is mapped to nominally maximum perceived impairment. The correlation coefficients for the left and right scatter plots are 0.95 and 0.78, respectively.

Further information can be found on the Video Quality Research home page at http://www.its.bldrdoc.gov/n3/video

Recent Publications:

S. Wolf and M. Pinson, "Video quality measurement techniques," NTIA Report 02-392, Jun. 2002

M. Pinson and S. Wolf, "Video quality measurement user's manual," NTIA Handbook 02-01, Feb. 2002.

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